Amendment To The Specification

BACKGROUND OF THE INVENTION (page 2)

No changes, additions or deletions

DISCUSSION OF PRIOR ART (page 4)

Replace all the paragraphs of this section with the following paragraph:

Our search of patent databases discovered over one hundred patents that deal with detection of faults in electrical signals, detection of damage and deterioration in electrical conductors and likewise in electrical insulation, along with patents of similar nature applied to deterioration and damage of pipelines, fiber optic networks and other conduits.

DISCUSSION OF LIMITATIONS OF PRIOR ART (page 4)

Replace all paragraphs of this section with the following paragraphs:

Review of U.S and foreign patents found instances of use of electrical measurement and incandescent light measurement for inspecting and monitoring the health and condition of various types of conduits such as electrical wiring conduits, pipes and elevator hauler cables. We found that currently nothing patented or in wide use for the stated objective is based on measurement of florescence, phosphorescence and luminescence which are important and reliable phenomena.

A patent disclosure for a device for the said purposes was not evidenced during our year 2001 searches of patent databases. Further, a patent disclosure for a device for the said purposes based on using Optical Phenomena measurement was not evidenced during our year 2001 searches of patent databases. Persons familiar with optical sensors would agree that potentially the said purposes can be accomplished by measuring and interpreting Optical Phenomena resulting directly or indirectly by stress factors.

Watkins U.S. Patent [5,862,030] teaches an electrical safety device comprised of electrically conductive strip disposed in the insulation of a wire or in the insulation of a sheath enclosing a bundle of electrical conductors, where the sensor strip comprises a distributed

conductive polymer over-temperature sensing portion comprising an (electrically) conductive polymer having a positive temperature coefficient of resistivity which increases with temperature sufficient to result in a switching temperature. Said Watkins' patent also teaches use of electricity with a mechanical damage (chafing) sensing portion comprised of a strip disposed in the sheath in a mechanical damage sensing pattern which becomes damaged or open upon mechanical damage of the sheath before the bundle of conductors are damaged. The present invention overcomes the shortcomings of said Watkin's patent requiring a conductive polymer by teaching use of sensing over-temperature and damage by measurement of Optical Phenomena parameters in electrically non-conductive polymers. Removing the use of electrically conductive polymers for inspection is important because electricity can be a safety concern, especially in fire or explosion prone situations that could be caused by electrical signals.

Born, et al U.S. Patent No. 6,265,880 teaches use of a length of electrical conducting media (such as a wire) along a conduit to detect mechanical damage (chafing), and improves on said Boenning's patent by teaching periodic testing, and detecting chafing on conduits other than electrical cables, and detecting chafing against a non-electrically grounded structure. Born's patents like Boenning's patent teaches use of electricity with a mechanical damage (chafing) sensing portion comprised of a strip disposed in the sheath in a mechanical damage sensing pattern which becomes damaged or open upon mechanical damage of the sheath before the bundle of conductors are damaged. The present invention overcomes limitations of use of electrical signals by Born's patent by teaching use of measuring change in Optical Phenomena without the need for end-to-end electrical connectivity. Removing the use of electrical circuits along the conduit is important because electrified wires can be a safety concern, especially in fire or explosion prone situations that could be caused by electrical signals.

Born's patent does not teach a means to perform detection and location of damage without need for end-to-end test of an electrically conductive sensor material or by light measurement without end-to-end measurement of light transmitted using a fiber optic cable. The present invention overcomes limitations of said Bond's patent teaching use of Optical Phenomena and does so requiring end-to-end measurement. The present invention eliminates the need for electrical sensing which can be a safety concern, and reduces cost and weight and potentially reduces the time for installation.

Born, et al U.S. Patent No. 6,275,050 teaches use of a harmonic analysis to detect corrosion in metal junctions. Use of harmonic analysis as described by Born requires using at

least one electrical signal. The present invention improves on Bond's method by not using any electrical signal, by teaching use of Optical Phenomena. Removing the use of electrical signal for inspection is important because can be a safety concern, especially in fire or explosion prone situations that could be caused by electrical signals.

Khuri-Yakub's U.S. Patent No. 5,271,274 (1993) teaches use of acoustic waves through a film on a substrate, with processing of the output signal to give a thickness value. Khuri-Yakub's patent does not teach use of measurement of stimulated Optical Phenomena or other optical parameters. The present invention overcomes limitations of the said Khuri-Yakub's patent by teaching use of measurement of stimulated Optical Phenomena. The present invention eliminates the need for acoustic processing thus reducing cost and weight for an acoustic processor.

Morris, Jr., et al, U.S. Patent No. 6,512,444 teaches use of a fault sensing wire that utilizes one or more sensor strips which provide an electrical impedance change when heated. Morris's patent does not teach a means for fault sensing using measuring optical parameters. Morris's patent does not teach a means for locating the point of the fault. The present invention overcomes limitations of the said Morris's patent by using light parameter measurement. The present invention eliminates use of electricity which can be a safety hazard; and simplifies the design, which reduces cost and weight and potentially reduces the time for installation. The present invention improves over Morris' methods by substituting measurement of Optical Phenomena for electrical impedance measurement which would eliminate the use of electrical measurement which can be a safety concern, especially in a fire or explosion prone environment. The present invention further overcomes a limitation of Morris's patent requiring a microcontroller because the present invention also can be embodied without the need for a microcontroller by using optical or analog processing. Eliminating the need for Morris's microcontroller and programming thereof which can result in significant cost savings which is important to the end user.

Johnson's U.S. Patent No. 5,712,934 discloses an optical sensor comprising a light source, light detector and signal generator and an optical fiber extending between the light source and the detector. Said Johnson's patent does not teach use of Optical Phenomena such as by adding a light-emitting doping in the fiber or its cladding to create enhanced light to perform detection of chemical, mechanical or other damage; nor the use of a single ended measurement device of a light source and a light detector. The present invention overcomes limitations of the said Johnson's patent by measurement of light parameter or measurement of Optical Phenomena

and does so without the need for end-to-end measurement. The present invention can reduce cost and weight and potentially reduces the time for installation which is important to an end user.

De Angelis's U.S. patent [6,392,551] teaches a synthetic fiber cable made with a bundle of load bear-ing synthetic material fibers and at least one electrically conductive temperature sensor element extending the a length of the cable. The temperature sensor element forms, in dependence on the temperature a conductive connection over the length of the cable, which connection is constantly monitored by a measurement circuit. The present invention improves on said De Angelis's patent by not using a electrically conductive element which can be a safety concern especially in a fire or explosion prone environment. Further, the present invention improves on said De Angelis's patent by using a very thin light conducting polymer strand which saves weight over metal strands, weight being a significant advantage for some end uses.

May's U.S. Patent No. 6,286,557 discloses a sheath having an electrically conductive portion extending from an inner surface to an outer surface. May's patent does not teach how to create a sheath that uses measurement of parameters of Optical Phenomena. The present invention overcomes limitations of the said May's patent by using measurement of Optical Phenomena parameters. The present invention improves on said May's patent because it eliminates the need for electrically end-to-end conductive sensors by introducing use of micro-optical fibers, thus saving weight which can be a significant advantage for some end uses.

Runner's U.S. Patent No. 5,245,293 describes a method and apparatus for detecting changes in structural strength of a bonding joint using measurement of dielectric properties such as electrical resistance and capacitance. Runner's patent does not teach how to use optical parameter measurement for detecting changes in structural strength of a bonding joint. The present invention overcomes limitations of the said Runner's patent by using parameter measurement of Optical Phenomena. The present invention improves on said Runner's patent by substituting optical measurement for end-to-end electrical measurement which would eliminate the use of electrical measurement of dielectric properties which can be a safety hazard especially in fire or explosion prone environments.

The disclosure of U.S. Patent No. 4,988,949 by Boenning et al teaches detecting mechanical damage (chafing) on electrical cables (by sensing electrical erosion of a semiconductive material) against grounded structures under constant monitoring. Boenning's patent does not teach a means to perform detection and location of damage without need for end-to-end test a semiconductor detector circuit. The present invention overcomes limitations of the

said Boenning patent by using light parameter measurement and does so without the need for end-to-end measurement. The present invention eliminates the need for electrical sensing which can be a safety concern, and in the preferred embodiment eliminates end-to-end tests which reduces cost and weight and potentially reduces the time for installation.

OBJECTS AND ADVANTAGES [Page 8, line 12] I changed the f.ashion error to "fashion" as you directed.

Therefore, please replace page 8, lines 1-13 with this paragraph :

Therefore, one object of the present invention is to combine detection of onset of damage by a wide variety of stressors, and perform diagnosis and prognosis of damage to a conduit before damage to the conduit occurs.

Another object is to provide a method to deduct the identity of active stressors.

Another object is to provide a means to mark places where damage has occurred and coincidentally mark a place on the stressor as well.

Another object is to provide a means to diagnose damage, to predict future damage, and to prognose risk of future conduit failure and system failure.

Another object is to provide a means to sense and locate damage that does not depend on electricity to excite sensor material or read the sensor.

A final object is to provide a means and method that operates on or in the conduit, in a timely fashion to warn of damage in progress and possibly pre-empt catastrophic damage that would otherwise occur.

SUMMARY OF THE INVENTION (Page 11)

Please replace this entire section with the paragraphs that follow

Briefly stated, the present invention is a system that provides a mechanism and a method to detect multiple forms of damage to a conduit and perform diagnosis, prognosis related to condition and remaining useful life of a conduit, thereby reducing the chance of failure of any system that would be damaged or whose function would be impaired by damage to the conduit. Such a system could carry electrical power, optical or electromechanical signals, fuel or other fluids, may be hydraulic or pneumatic, or may carry solids such as particles.

The present invention is based on the use of Optical Phenomena. Optical Phenomena fall into two categories. The first type is the generation of light through excitation by photons, mechanical, or chemical means resulting in phenomena widely known as phosphorescence, luminescence, and incandescence. The second type is distortion or blockage, or amplification, or other change caused by mechanical means such filtering, splitting, polarization, refraction, reflection and absorption of rays of light. Optical Phenomena in the context of the present patent include:

Incandescence: light emission due to temperature (e.g. light bulbs)

Luminescence (Scintillation): light emission due to causes other than temperature. These causes could be electromagnetic radiation, electric fields, chemical reactions, bombardment by sub-atomic particles, or mechanical action. If the sub-atomic particle is an electron, it is called cathodoluminescence. If the mechanical action is breakage or shattering, it is called triboluminescence. if one form of luminescence induces another, it is called "luminescence luminescence".

Fluorescence: luminescence that ceases within 10 nanoseconds after the stimulus has ceased.

Phosphorescence: luminescence that continues for more than 10 nanoseconds after the stimulus has been cutoff.

Measurements of Optical Phenomena includes measurement of wavelength frequency (Hertz), wavelength (Angstroms), power (Watts), and intensity (lumens). All photometric concepts are based on the concept of a standard measure called a "candle" The ratio of the candle power of a source to its area is called the luminance of the source. The power of the luminance of the Optical Phenomena of the sensors at a particular frequency or band of frequencies can be measured by several common and widely known techniques. One common and widely known technique is to use a photoresistor or photodetector which are semiconductor devices that convert light signals to a voltage or current. The output voltage or current from the photodector device is integrated, averaged, digitized and otherwise manipulated to provide the measurement parameter. " Optical Phenomena are also incited by changes in the media such as vibration stretching a moire' fringe, or a bend causing light to not move as directly as in a straight fiber, being lost in bounces.

The present invention is a method and system constructed with a fully distributed three-tier architecture. The top level is at least one central processor. The primary function of the central processor is to gather life histories and process the life history data to diagnose and prognose the health and safety of all the conduits. Data for the central processor is provided by at least one Monitoring Device. The Monitoring Device is used for controlled measurement and processing of data from a multitude of sensors which, under appropriate conditions, exhibit an Optical Phenomena. At the lowest tier are embedded microsystems, electronic circuits that also can stimulate, measure, and processes photometric phenomena. The sensors are sheets, tubes, or strands of sensitized medium.

The architecture being fully distributed means that any processor in the hierarchy can perform the functions of the others, limited only by its own design constraints. At a practical level, all three levels can stimulate the sensors, take photometric measurements, and process the data of the measurements with algorithms for the purpose of making assessments about the current and future health of the conduits monitored. This has been demonstrated in practice.

This three-tier hierarchy is well suited to implement utilizing advanced artificial intelligence algorithms for pattern recognition, machine learning and other techniques to use probability and statistics for highly accurate diagnostics and prognostics. The current implementation incorporates mechanisms and algorithms for artificial intelligence to learn causal factors, and learn the effects of damage from experience dealing with past instances of damage and repair.

Monitoring Devices

The Monitoring Devices provide a means for stimulating the sensitized mediums; and performing photometric measurements of the Optical Phenomena output from of the set of sensors to which it has control; processing individually or in combination the said photometric measurements using signal conditioning, smoothing, and other functions necessary to create quality photometric measurements estimates; and characterizing the degree of change with statistical algorithms.

When collecting Optical Phenomena data the Local Monitoring Devices perform additional processing mathematical and logic algorithms using static and dynamic algorithms that operate according to context.

The output from the Local Monitoring Device is one of an electrical direct current signal, a digital signal, an optical signal. The output is one of an electrically or optically encoded digital signal formed entirely without need for a programmed microprocessor or other programmed device. In 1968 Blemel and Asam were granted a U.S. patent that included a non-programmed digital mathematical transform generator built entirely with Boolean logic using semiconductor gates.

Sensors

Sensors used in monitoring conduits are built as sensitized strands, elongated forms of substances such as strips, fibers, tubes, filaments of diverse materials and dimensions.

Sensitized strands in this context are strands that exhibit measurable Optical Phenomena. The strands in this context are sensitized medium that are made with materials that are formulated to exhibit Optical Phenomena when exposed to certain frequencies of light. The strands are not intended to carry significant electrical signals and serve another purpose like a marker strand; and said excitable and non-excitable strands can be entirely selected of optical, electrically opaque medium sensitized with coatings, claddings, and non-metallic materials so as to eliminate any possibility of electrification of the strands.

Damage caused by external stressors including corrosive chemicals, heat, structures, friction, erosion, flexing, and maintenance actions is detected by adding to, laying on, building in, or wrapping the conduit with a set of strands of sensitized medium such as treated, clad, or coated hollow or solid fibers. The sensing elements are positioned so that damage

caused by a stressor breaks, erodes, corrodes, punctures or breaks one or more of the sensing elements.

Measuring is accomplished by stimulating the photosensitive sensitized material with wavelengths of light specific to its nature and then measuring the amount of Optical Phenomena [of the end to end integrity] of still measurable sensing elements or performing other tests on them determines whether each has failed, thereby indicating that the conduit's remaining integrity will be compromised unless remedial action is taken.

BRIEF DESCRIPTION OF DRAWINGS

Replace the paragraphs of this section with the following paragraphs:

The novel aspects of this invention are set forth with particularity in the appended claims. The invention itself, together with further objects and advantages thereof may be more readily comprehended by reference to the following detailed description of embodiments of the invention, taken in conjunction with an accompanying drawing.

Referring now to FIG. 1, which shows five diagrammatic views of how damage to one or more sensitized media provides evidence for determining the cause of damage. For illustration, FIG. 1 shows by example a buffered glass strand [22], one strand with florescent core with a plating of noble metal [21], one strand with a florescent core with a plating of base metal [20] and one strand with a hollow core containing a dye that fluoresces in ultraviolet light [19]. In practice FIG. IA, FIG. 1B, FIG. 1C, FIG. 1D, and FIG. 1E show how evidence from damage to the sensitized media is readily combined to infer the probable cause of damage. Logic combining the temporal order of damage indicated in a test and type of the conductive elements affected with damage can be used to assess the type, degree, and speed of ingress of damage. For example, discontinuity to one material caused by hydraulic fluid would not affect a metallic surface; and damage due to acid corrosion of a metallic surface would not affect a sensitized media made with a noble metal, a plastic or a polymer. This evidence can be processed with artificial intelligence algorithms such as a Neural Network, Bayesian Belief Network or Boolean Logic truth-table to derive the probable causal factors.

Referring now to FIG. 1A which shows diagrammatically the concept of undamaged strands embodied in the manner of the present invention. The figure shows by example a buffered

glass strand [22], one strand with florescent core with a a plating of noble metal [21], one strand with a florescent core with a plating of base metal [20] and one strand with a hollow core containing a dye that fluoresces in ultraviolet light [19]. In practice these sensitized media will be individually selected based on the specific application and operation environment of the conduit. The four medium [41 to 44] used throughout FIG 1A through 1E are for example only.

Referring now to FIG. 1B which shows diagrammatically the damage caused by a substance that is less hard than glass, because the glass [22] is unaffected; but harder than the sensor strands plated with metal [21] [20]; and harder than the plastic substance of the marker sensor strand [19]. The leakage or debris from the affected marker strand [19] indicates the location of the damage [23] an under a ultraviolet lamp will exhibit florescent Optical Phenomena at the location of damage which is very near the damage to the others. Photometric measurement of Optical Phenomena remaining in the damaged sensor strands also detects the damage forming the basis , by simple logic, to diagnose chafing.

Referring now to FIG. 1C which shows diagrammatically the damage across all four strands, which indicates that the damage is likely caused by incision or slicing by a substance harder than glass. Again, the affected marker strand indicates the location of the damage by the presence of debris and the spread of the dye. Photometric measurement of Optical Phenomena remaining in the damaged sensor strands also detects the damage forming the basis, by simple logic, to diagnose of an incision. The leakage or debris from the affected marker strand [19] indicates the location of the damage [23] an under a ultraviolet lamp will exhibit florescent Optical Phenomena at the location of damage which is very near the damage to the others.

Referring now to FIG. 1D which shows damage to the marking indicator strand only, which indicates the damage is likely caused by certain solvents that are not strong enough to affect the basemetals, noble metals or glass, but do dissolve the coating of the said marker strand. Photometric measurement of Optical Phenomena remaining in the damaged sensor strands also detects the damage forming the basis, by simple logic, to diagnose solvent damage. The leakage or debris from the affected marker strand [19] indicates the location of the damage [23] an under a ultraviolet lamp will exhibit florescent Optical Phenomena at the location of damage which is very near the damage to the others.

Referring now to FIG. 1E which shows damage to only the base metal, indicating that the stressor is probably a corrosive because no other strand was affected and the noble metal is intact.

The marker strand is unaffected, however a marker substance could have been included in the composition of the base metal, or if a hollow strand filled with marker dye were utilized, a mark would be released. Measurement of the change in intensity or wavelength of the Optical Phenomena remaining also detects the damage.

Referring now to FIG. 2A, which shows a pattern of heterogeneous sensitized media [3] [4] [5] laid linearly in parallel fashion as helices with as small a pitch between media as possible, formed on the outer or inner surface [16]. The surface could be a sleeve or tube made of suitable dielectric or other material suitable for the purpose of separating the sensitized strands. The said pattern of sensitized media could be on the exterior, the interior, or formed as a matrix with the inter-spatial material to form a sleeve or tube. A plurality of sensitized media can be placed on both upper and lower surfaces. The calculation of distance by the sensor instrument algorithm can be used to discern which side or edge of the conduits is being damaged. The pattern of sensitized media [3] [4] [5] can be formed on a sleeve [16] so as to enclose a a single conduit or a bundle of conduits. If the sleeve [16] is made of shrinkable material it can be slipped and shrunk over the outer surface. The pattern of sensitized media [3] [4] [5] can be of diverse materials such as optical strands, or organic strands formulated to sense or to act as waveguides or transmission lines. The type of signal is specific to the sensitized media and could be pressure, ionizing radiation, sound, light, radio frequency, or other signal appropriate to the sensitized media. The arrangement of the strands of sensitized media in patterns can be coaxial or at any angle consistent for measurement of the path to damage conduit(s). The patterns can be touching one another if they are surface compatible such as non-metal media surface touching metal surface media.

Referring now to FIG. 2B, which shows diagrammatically a pattern of sensitized media [3] [4] [5] formed onto a supporting surface [18] of suitable material such as a dielectric, which is placed onto the insulation [2] and/or the conduit [1]. The tape could be adhesive or other means such as thermal shrinking could be used as the form of attachment. Attachment points [6] for the leads from the instrument can be positioned if desired anywhere along the said sensitized media. The tape can be applied in a helical fashion as shown if omni-directional coverage is needed.

Referring now to FIG. 2C which shows diagrammatically an alternative pattern of sensitized media [3] [4] [5] laid coaxially along a supporting surface [18]. The pattern can be repeated to encircle the insulation for omni-directional coverage. The use of co-linear sensitized

media has the advantage that it can be slit to fit over the conduit. The discussion about FIG. 2A applies to this configuration as well.

Referring now to FIG. 3, which shows diagrammatically that the Measurement Device can separated from the central processor yet connected to the arrangement of strands. The Measuremet Device electronics can be located on a conduit connected to the a conduit, serving both conduits and thereby saving costs such weight, space, and money. FIG. 3 shows a sensored conduit built discrete sensors [34] and with a pattern of sensitized media [3] [4] [5] embedded on the inner surface of a sleeve in accordance with this invention is illustrated as applied to an insulation [2] surrounding a conduit [1]. The pattern of different sensitized media [3] [4] [5] are shown along the length of the insulation in side by side spirals. This provides initial protection of the plurality of sensitized media so that if ingress of damage, due to stressors, occurs the various materials are at risk; and as discontinuity of any sensitized media occurs the spatial location of the damage can be measured by reflectometry, signal strength remaining or other remote means. The cause of the damage can be interpreted by algorithms that take into account possible stressors and the damage inflicted to the sensitized media. This figure shows a coupling [15] that contains Central Processor [13] as well as a discrete sensor [34]. The coupling is attached to the individual members of the discrete sensor and to the sensitized media with a suitable attachment point [6]. The method of attachment can be any low impedance connection. The attachment points may be of a form such as detents, clamps, holes, posts, or screws, or in the alternative the coupling may be welded or otherwise permanently fastened to the sensitized media. The coupling itself, which may be of the so-called BNC type, have an outer shell and a center holding a plurality of conduits. The outer shell of coupling [15] is connected to one or more of the conductive elements such as the sensitized media [4]. An attachment point [6] provides a convenient way to connect the discrete sensor [34] to the Central Processor [13] instrument and interconnections [7] from the Monitoring Device[8]. Note damage to the sensitized media [3] causing a point of the interruption [12]. The distance to the damage can be as short as a few millimeters and at least a few meters. The distance can possibly be as long as several miles for laser signals depending on signal loss in the fiber.

Referring now to FIG. 4 which diagrammatically represents a tree of several connected branches of conduits. To check installation or to perform a test for absence of damage, a single-end or end-to-end test can be made using a signal of type appropriate for an element sent from a Monitoring Device [8] and carried along the conduit interconnection [7] from point of attachment [6] to the sensor with the sensitized medium. Depending on the sensory element, the signal can be of various type such as electricity, pressure, shock, collimated or un-collimated light, laser, sound, and high frequency waves that cause the Optical Phenomena to appear. The amount of Optical Phenomena flux generated by the sensor will be photometrically measured by the initiating monitoring device or another monitoring device. Damage [12] on section (e, f) is detected, located and its cause inferred when erosion, corrosion, breakage or other factor causes at least one sensitized media to change the Optical Phenomena response characteristic, such as causing the reflection of the signal to be shorter than before with an abbreviated measured distance to the point of discontinuity caused by damage [12]. In the case of ambiguity caused by the branches, a sensor signal source can be located at another place in the tree to accurately locate the place of damage.

Referring now to FIG. 5, which shows diagrammatically embodiment 2 of sensored ribbonized, organized, mixed modality (e.g. electrical and fiber optic) conductors built with discrete sensors [34] and with a pattern of sensitized media [3] [4] [5] embedded on the inner surface of a sleeve in accordance with this invention is illustrated as applied to an insulation [2] surrounding a conduit [1]. The pattern of different sensitized media [3] [4] [5] are shown along the length of the insulation. The statements about FIG. 3 apply. Notice the shape of the coupling housing the electronics shown offset in the dashed space. These electronics could also be attached during inspection if it were not embedded in the coupling [15].

Referring now to FIG. 6, which shows diagrammatically alternative embodiment 3 similar to alternative embodiment 2 shown in FIG. 5 but with the monitoring device now serving two sides, thereby achieving a saving of one Monitoring Device [8].

Referring now to FIG. 7 which shows diagrammatically a several layered ribbonized conduit made with a multiple conductors [25] in each layer, separated by a separator [34] which could be a ground plane or other purpose with the sensor strands [27] plated, printed, embossed, or otherwise added on either or both surfaces, and the conduit encased in an outer protective

sheath [24]. This shows that the sensor medium can be distributed within a conduit to detect penetration from without potentially before damage results.

Referring now to FIG. 8A which shows diagrammatically a flat supporting surface [18] can be constructed with sensitized optically non-opaque media [39], as well as sensitized medium that when stimulated exhibit Optical Phenomena [35], electrically conductive [36], and electrically opaque [37] and electrically dielectric [38].

Referring now to FIG. 8B which shows diagrammatically a patterns of medium that optically transparent [39], sensitized to exhibit Optical Phenomena [35], electrically conductive [36], and electrically opaque [37], electrically dielectric [38], and optically non-opaque, can placed on a supporting surface [18] to form a sensitized strand. The patterns could be of any size with respect to said supporting surface and can be electrically conductive as long as they do not introduce unintended side effects or electrical conductivity end-to-end for the length of the sensor.

Referring now to FIG. 9 which shows diagrammatically a flat ribbon of multiple conductors [25] each with a core [1]to be protected and insulation [2] protecting the said cores as well as multiple instances of sensor strands [27] among said conductors, in this case the said sensor strands are elongated and thinner than the said conductors. These could be laid in spiral or other fashion, placed to best sense the conductors they serve and protect. The sensors can be heterogeneous of any of several types.

Referring now to FIG. 10 which shows diagrammatically a flat ribbon of multiple conductors [25] could be mounted on a mounting surface [18] which itself could be constructed as a sensor, and multiple instances of sensor strands in this case elongated and thinner than the conductors [25]. The conductors and the sensors can be heterogeneous.

Referring now to FIG. 11A which shows diagrammatically representations of a sensor made up of an optically conducting core [28] through which the Optical Phenomena flux [26] is conducted to the point of photometric measurement [29]. Along the sensor are shown segments of heterogeneous sensitized medium [34 through 40] that when affected by a stressor cause either an increase or decrease in the optical phenomena represented by 3 dashed arrows at the point of photometric measurement [29], and no flux emitting at the other end, shown constructed with an optically opaque material [31], perhaps with a inner mirrored surface. For illustration purposes FIG. 11A shows a sensor where all sensitized medium are unaffected with internally generated

Optical Phenomena flux emitting from only one end of the core [26] represented by three rays represented by dashed arrows at the point of photometric measurement [29].

Referring now to FIG. 11B which shows diagrammatically how damage to one sensitized medium [38] allows egress of some amount of optical phenomena flux [30] contained in the optically conductive core [28] to escape, thereby lessening the amount of Optical Phenomena Flux (represented by two rays) at the point of measurement [29] and thus decreasing the photometric measurement.

Referring now to FIG. 11C which shows diagrammatically how damage to one of the sensitized medium [35] allows optical flux (light) [32] to enter the central sensitized medium of sensor, having the effect of increasing the Optical Phenomena flux at the point of photometric measurement [29] as shown by four arrows, and thus increasing the photometric measurement.

Referring now to FIG. 11D which shows diagrammatically how breakage [31] of the sensitized medium [36] allows optical phenomena flux [26] from the optically conducting core [28] to escape from at the broken surface, thereby greatly lessening the amount of Optical Phenomena Flux (represented by one ray) at the point of measurement [29] and thus decreasing the then current photometric measurement.

Each figure is diagrammatic to the extent that the inner insulated core element [1], insulation [2] and sensitized media [3], [4] and [5] are shown as each having no particular material, essentially no thickness, no particular separation distance between materials, and no particular predefined pattern. However, the material, thickness of the said sensitized media and pattern can be selected to provide calibration of the degree of ingress of the damage. For example, a thicker aluminum or corrodible metallic element will withstand more corrosion than a thinner element of the same width and material. For example, a tight pattern of millimeter size elements will reduce chance for not detecting millimeter size damage. FIG. 2B, FIG. 2C, FIG.3, FIG. 5 and FIG. 6 have diagrammatic points [6] for attaching the signal leads and the coupling [15] is not representative of any particular configuration. Each figure is also diagrammatic with respect to other symbols that represent interconnections [7], Monitoring Device [8], stimulus signals [9][10] [11], damage [12] and Central Processor[13] as a part of the coupling [15]. The surfaces and their materials [16] [17] [18] have no particular description except as to be not causing cross-talk or

other confounding situations. The sensitized medium [34 through 40] have no particular property other than being suitable for use. The said sensitized medium [34 through 40] do not have to be contiguous and may be laid in any useful pattern on the surface or interior of the medium where they are placed. The medium of the optically conducting core [28] can be formulated so as to exhibit Optical Phenomena when stimulated.

Reference Numerals in **Drawings (page 15)**

On your suggestion I made the change on page 16 lines 8-9 the label "tape supporting sensitized media" as "17" was incorrect as found by the examiner and has been changed.

Please replace with the following numbers

[1] core (conductor) of conduit to be protected from damage
[2] insulation protecting the core [I]
[3] sensitized medium 1
[4] sensitized medium 2
[5] sensitized medium 3
[6] point of attachment for measurement instrument
[7] interconnections from point of attachment
[8] Monitoring Device
[9] signal applied to sensitized medium 1
[10] signal applied to sensitized medium 2
[11] signal applied to sensitized medium 3
[12] damage
[13] Central Processor
[14] insulating material
[15] coupling
[16] surface of sleeve supporting sensitized media
[17] tape supporting sensitized media
[18] supporting surface
[19] sensor strand of solvent soluble plastic and florescent marker dye.
[20] sensor strand with core doped with florescent chemical and plated with base metal
[21] sensor strand, with core doped with florescent chemical and plated with noble metal
[22] sensor strand of solid glass doped with florescent chemical
[23] leak of core material
[24] sheath
[25] conductor
[26] flux of Optical Phenomena
[27] sensor strands
[28] optically conducting core
[29] point of Photometric Measurement
[30] emitted Optical Phenomena Flux
[31] optically opaque surface
[32] lightwaves
[33] microcontroller
[34] discrete sensor

[35] medium which exhibits Optical Phenomena (when stimulated)
[36] electrically conductive medium
[37] electrically opaque medium
[38] dielectric medium
[39] optically non-opaque medium
[40] optical mirror medium

DETAILED DESCRIPTION (Page 16)

Please replace with the following paragraphs

In order to achieve the objectives of the above mentioned, the present invention provides a system made up of a method and an apparatus, the apparatus comprising:

a multiplicity of heterogeneous discrete strands of material, each naturally sensitive, or specifically made to be sensitive to stressors or the damage caused thereby by coating,

cladding, or doping or other means with at least one media substance specific to a class of anticipated stressor or anticipated damage caused by stressors; and,

a dielectric substrate, braided matrix, mesh, substance or surface on which to form, overlay, weave, or attach said strands in a measurable pattern; and,

at least one electronic processing device of type called a microcontroller, or an interface to another suitable processor with ability to digitize, process, and perform prestored algorithms of calculus and logic, interface with microsensors and the said strands; and with a multiplicity of sensors for the purpose of collection of data on diverse variables anticipated in the domain of the conduit; and, a means for exciting the number of strands that are able be excited to obtain data on health, status, condition, and damage to the said strands.

Signals in this context are electronic, pneumatic, optical, audio or other signals that provide stimuli to extract data from excitable medium of the sensitized strands.

Sensors in this context are devices that serve a purpose to provide data on environmental, internal, physics, etc. and may be located at a distance communicating by wired or wireless means to the microcontrollers or other processors.

The said multiplicity of heterogeneous sensitized strands, heterogeneous discrete sensors and micro controllers serve as a means for sensing, detecting, locating, measuring and messaging in real time about deterioration and damage to sensitized medium, conduits and threats thereto.

In accordance with the present invention the strands of sensitized medium are sensitized so as to detect and differentiate causes of damage to a conduit and components thereof or damage occurring in the conduit due to internal factors.

According to conventional design practices, the micro controller can be constructed in an electrically isolated package and interfaced to only optically conductive sensitized strands using optical decoupling such that light rather than electricity is used to extract data from the strands.

In the preferred embodiment with a microcontroller or other processor, the said processor of the present invention provides a means to obtain, baseline and learn from data; the means to learn and fuse data to probabilistically assess causal factors of damage; the means to quantify the state of deterioration and damage that has occurred; the means to assess the risk that a situation exists that likely will soon cause deterioration or damage to happen; and the means to formulate and communicate messages about the state of deterioration, damage, risks of damage and causal factors.

In accordance with the present invention the apparatus is constructed as a layer, sleeve or tape made a multiplicity of said strands of media coated, doped, and otherwise sensitized to anticipated conditions within and external to a conduits, then adding the constructed apparatus as an appliqué, sheathing, weaving or winding to the outer or inner surface of the conduit.

In accordance with the present invention, the sensitized medium can be made up of piecewise pieces of heterogenious medium placed layered, side-by-side or end-to-end; each piece, when stimulated, either emitting optical phenomena, or exciting optical phenomena of the sensor or releasing optical phenomena from the sensor; and could be of any size with respect to said supporting surface. Further, the individual patterns can be electrically conductive as long as they do not introduce unintended side effects or electrical conductivity end-to-end for the length of the sensor. (Ref. FIG. 8B)

In accordance with the present invention ancillary electronics that are not an integral part of the apparatus such as personal computers, signal conditioners, used for instruments not

included in the apparatus should be selected so as to be able to be readily interfaced to the apparatus.

In accordance with the present invention, the microcontroller and other electronics should be packaged with foresight to prevent damage to itself or other entities.

In accordance with the present invention the substrate, mesh, or surface on which to form, overlay, or attach the strands is selected of suitably inert insulating material.

In accordance with the present invention, when used in communication with a commercially available computer, the data, causal inferences, probabilities and messages generated by the micro controller of the present invention can be used by the computer to probabilistically predict future local, system and end effects of faults and failures as well as remedial actions

PREFERRED EMBODIMENT (page 18)

Please replace this entire section with the paragraphs that follow.

In the preferred embodiment Central Processor is connected by wire or wirelessly to at least one Local Monitoring Device which is connected optically, electrically, or mechanically to a least one strand of sensitized media connected to placed on, into, woven as a sheath substantially surrounding a conduit and that when attached to, sleeved over, or embedded into a conduit provides a means to stimulate and measure Optical Phenomena whereby to detect, locate, and reason the existence, cause and degree of stress or damage to the sensitized medium themselves and by programs and algorithms in a computer to sense, detect, locate and reason risk of damage of the conduit to which they are attached, thereby reducing the chance of failure of any system which would be damaged or whose function would be impaired or degraded by damage to the conduit.

According to one embodiment of the invention, a method for detecting damage of a conduit comprises steps of placing adjacent the conduit surface an effective length of a pattern of sensitized medium being located so that a stressor cannot damage the conduit without substantially damaging a strand of sensitized medium; determining and storing baseline characteristics of the installed apparatus; performing Optical Phenomena measurements (photometrics) during operation in a periodic or continuous fashion on the sensitized medium; analyzing the measurements; comparing the measurements against the stored baseline measurements; determining damage by utilizing artificial intelligence algorithms for pattern recognition, machine learning and other techniques to use probability and statistics for highly accurate diagnostics, or by referencing damage models, or by examining the integrity of the sensitized medium or other processing; using case based reasoning and other logical or inferential reasoning for; deducing the likely identity of the stressors; diagnosing the extent and meaning of the damage to the sensors and by inference and implication damage with respect to the conduit; predicting the degree and intensity of the expected future damage to the conduit; prognosing the remaining useful life of the conduit without remediation; updating the algorithms and parameters; taking any programmed actions such as if isolating damaged stressors, sensitized medium; and messaging the status of damage, integrity and remaining useful life for awareness by the operators of the system.

In any embodiment, simple mathematics are used to condition the output signal and convert the value of the Photometric Measurement to data useable as parameters. Once the photometric data is obtained, it can be manipulated with statistical algorithms to determine parameters which include the statistical mean, average, mode, and standard deviation. Further, real time differential and integral calculus using analog or digital signal processing techniques can be applied to the photometric data to determine characteristics such as rate of change. Results of combinations of algebraic, statistical and calculus algorithms that have processed the parameters can be used as parameters used by physics of failure models and damage models to interpret the meaning of the characteristic values in context of damage to the individual sensor strands, to the conduits in proximity, and to the system of conduits, and to the functions they provide. A person reasonability familiar with optics, physics and chemistry, experimentation, modeling and simulation as related to the construction and materials used in the sensor strands and conduits will be readily able to use reconstruct an embodiment of the invention for their application.

It is a significant advantage that stimulation of sensitized medium resulting in Optical Phenomena can be used in place of electrical measurements because of the inherent safety it offers.

Another significant advantage of the present invention, is that unlike electrical measurement systems used in prior art, the photometric measurements of the current patent do not need to be used end-to-end. This is accomplished using principles of direct measurement of light emissions; or indirect measurement such as measuring frequency change as a function of temperature of light reflected from a Gallium Arsenide coated surface of chips at a distance from said photometric device. Further, the measurements can be made without making direct contact as the measurements can be made at a standoff distance.

Optical Phenomena directly related to and used in the present invention are phosphorescence, luminescence, and incandescence. These phenomena are light that can be visible or invisible to the naked eye. The output spectrum of the Optical Phenomena determines which wavelengths must be measured. All photometric concepts are based on the concept of a standard measure called a "candle". The ratio of the candlepower of a source to its area is called the luminance of the source. The power of the luminance of the Optical Phenomena of the sensors at a particular frequency or band of frequencies can be measured by several common and widely known techniques. One common and widely known technique is to use a photoresistor or

photodetector which are semiconductor devices that convert light signals to a voltage or current. The output voltage or current from the photodector device is integrated, averaged, digitized and otherwise manipulated to provide the measurement parameter.

There are numerous patents for photometric devices. The said devices can be simple in design consisting of a light source selected with a frequency and power to stimulate the phenomena emission from the sensitized medium. An accurate photometric measurement can be made without a calibrating reference signal although said calibrating reference may be worthwhile to remove unwanted variability. The measurements made by the said photometric device may be caused by a specific source in the measurement device or may be from another source such as sunlight, pressures, heat, liquids, electromagnetic fields or other actions on the sensitized matter in the sensor. Depending on accuracy requirements, the measurements can be used "as is" or can be compensated using a calibration transform formula.

Some examples of the technique:

1. a photometric device will measure less power at certain frequencies if pressure significantly crimps or cuts an excited doped phosphorescent plastic sensor strand because a portion of the original light will be cut-off.

2. a photometric device will measure more power at certain frequencies if sunlight appearing through holes in an increasingly corroded surface of a sensor strand excites the luminescent doping inside.

3. a photometric device will measure more power at certain frequencies if a liquid engulfs portions of a non-opaquely coated sensor strand because the liquid will interact and interfere with loss of scattering light from the surface of strand, with reflections re-entering the strand surface.

4. a photometric device will measure more power at certain frequencies if ionizing radiation causes scintillation from atomic decay within an ionizing gas contained structure of the sensor strand or rare earth like Yttrium used to dope the material of the sensor strand .

5. a photometric device will measure less power at certain frequencies if fracturing occurs in an illuminated doped silica core of a sensor strand because the fractures cause a combination of blockage and backscatter.

6. a photometric device will measure changes in power at certain frequencies if fluorescence in a sensor is caused by excitation of a changing field strength of electromagnetic waves.

7. a photometric device will measure increase in power at certain frequencies if fluorescence in a sensor is caused by movement or vibration as witnessed in light generated by chemical light sticks light up when flexed.

Simple mathematics are used to condition the output signal and convert the value to data useable as parameters. A person familiar with measuring light can readily select a photodector or photoresistor that responds best to the wavelength spectrum of the Optical Phenomena of the doping compound used in the sensor. Once the photometric data is obtained, it can be manipulated with statistical algorithms to determine parameters which include the statistical mean, average, mode, and standard deviation. Further, real time differential and integral calculus using analog or digital signal processing techniques can be applied to the photometric data to determine characteristics such as rate of change. Results of combinations of algebraic, statistical and calculus algorithms that have processed the parameters can be used as parameters used by physics of failure models and damage models to interpret the meaning of the characteristic values in context of damage to the individual sensor strands, to the conduits in proximity, and to the system of conduits, and to the functions they provide. A person reasonability familiar with optics, physics and chemistry, experimentation, modeling and simulation as related to the construction and materials used in the sensor strands and conduits will be readily able to use reconstruct an embodiment of the invention for their application.

Other Embodiments

Other embodiments can utilize a manual readout device such as a commercially available personal computer or palm computer. Testing by automated readout can be instrumented in any of several implementations depending on the particular applications by interfacing with the microcontroller [33] by way of its input/output connectors.

Another embodiment (embodiment 1) would be to place sensitized strands atop one another so that when each in turn is damaged the depth of damage is determined. Cross-talk caused by separated adjacent conduits will not generally be a problem because measurements will usually be performed serially. Non-interfering patterns such as one for voltage and one for light

waves can be laid touching side by side to avoid even a tiny gap that might lead to having an undetected point of damage. Conflicting conducting patterns such as gold and aluminum which both conduct electricity will need spatial clearance or a suitable spacing material to avoid forming junctions, cross-talk or other confounding situations. The pattern of conducting elements can be applied singularly or en masse as an applique embossed on a non-conducting substrate such as polyamide or a fluoropolymer such as EFTE. Or, the pattern of conducting elements can be extruded or embossed directly onto the insulation surface.

Whatever the type of pattern (helical, coaxial, wavy , etc.) is used all distances to a point of damage are also defined.

Embodiment 2, shown in FIG. 9 would place two or more rows of sensitized strands among the conductors so that when each in turn is damaged the direction of damage is determined. This also can be used to diagnose that internal damage has begun.

Embodiment 3, shown diagrammatically in FIG. 10 would be to place the sensitized strands in or on the supporting surface [18] that holds the conductors firm. Patterns of sensitized medium can be embedded geometrically on the surface of the medium or in the medium of the sensor strands [27] so as to cause changes in measured Optical Phenomena that is used to diagnose that risk of damage to the conductors has begun.

Embodiment 4 is shown diagrammatically in the figures of FIG. 11. Referring now to FIG. 11A which shows how multiple instances of sensitized medium [34] [35] [36] [37] [38] [39] [40] are placed along a sensitized strand. The sensitized strand has an optically conducting core [28] which is made with a medium that may or may not exhibit Optical Phenomena when excited. The said core coated or plated with an optically opaque medium [31] on the surface wherever exposed along the sensitized strand so that the strand is opaque to stimulation of light external to the strand. One end is the point of photometric measurement [29] where Optical Phenomena flux [26] coming from the optically conducting core [28] within the strand.

Referring now to FIG. 11B which shows diagrammatically how one of the sensitized media [38] being damaged allows emission of Optical Phenomena [30] from the surface of the strand, thus reducing the amount of Optical Phenomena flux [26] at the point of photometric measurement [29] thus forming a differential measurement of the Optical Phenomena compared to the undamaged strand of FIG. 11A.

Referring now to FIG. 11C which shows diagrammatically how one of the sensitized media [35] being damaged allows light waves [32] to enter through the damage, said lightwaves increasing the amount of flux [26] at the point of photometric measurement [29], the amount of said increase can be used as an indication as to the extent of damage to sensor.

Referring now to FIG. 11C which shows diagrammatically how one of the sensitized media [35] being damaged allows rays of Optical Phenomena [30] to leave through the damaged surface, said decreasing the amount of flux [26] at certain wavelengths at the point of photometric measurement [29], the amount of said decrease can be used as an indication as to the extent of damage to sensor.

A person familiar with use of electronic computer circuits would understand that in any embodiment, one or more additional couplings [15] with or without a microcontroller or discrete sensors [34] can be attached to the pattern of sensitized media at locations spaced apart from the first coupling [15], so that differential measurements can be taken at the couplings. The additional information from measurements at another point of the branches will accurately resolve any ambiguities caused by a plurality of sensitized media in a branched tree of conduits.

Embodiment 4 shown in FIG. 6 is similar to alternative embodiment 2 shown in FIG. 5 but with the apparatus now serving two sides, thereby achieving a saving of one Monitoring Device [8] with electronics for sending the excitation signal [9] and Central Processor [13]. As electronics continue to shrink in size the said measurement device could become embedded a conduit.

Embodiment 5 shown in FIG. 7 places sensitized strands among the conductors so that when each in turn is damaged the depth of damage is determined. This also can be used to diagnose that internal damage has begun.

OPERATION - PREFERRED EMBODIMENT (page 24)

Please replace with following title and paragraphs

DESCRIPTION OF PREFERRED EMBODIMENTS

The preferred embodiment involves connecting a battery, power scavenging capacitor, solar cell array, or other suitable source of power, a wireless commercially available microcontroller such as a Sentient Instrument Controller which in turn is connected to a multiplicity of selected commercially available discrete sensors, and a multiplicity of commercially available sensitized strands coated, doped, or clad with specific sensor properties affixed in a largely parallel pattern on a suitable insulating substrate such as a fluoropolymer like EFTE, EFTE-CTFE, FEP, and PFA or Mylar or polyamide (which is florescent under ultraviolet light), either directly attached to a conduit, woven in an insulated mesh, or woven among conductor strands or on an insulating substrate that is subsequently affixed to a conductor or conduit. In service the preferred embodiment is linked by wire or wirelessly to a remote computer such as a commercially available palm, laptop, or desktop model.

The said microcontroller provides the means to collect and process data obtained from the said strands and from said discrete sensors with algorithms to detect and probabilistically determine extent of damage as well as predict future damage and the progression of effects of failures on the system served by the conduit.

The said discrete sensors provide the means to sense local configuration, usage, threat and environmental data. Types of said discrete sensors include devices for measuring humidity and temperature and other evidence such as odors from combustion byproducts. The said discrete sensors provide the means to detect deterioration and damage as well as detect factors that would affect the conduit and the service it provides.

The said multiplicity of strands are selected for each application primarily as a means to provide data about deterioration, damage, or causal factors; and secondarily to provide a means to indicate places where deterioration, damage or threat of damage exists. In a preferred embodiment, all strands must be nearly of the same diameter, and the strands would be laid out in a measurable pattern that surrounds the conduit such as those shown in the FIG. I, FIG. 2, FIG. 3, FIG 5 and FIG.6. Ideally the pattern strands around the conduit should repeat their pattern in a space of less than one centimeter.

In the preferred embodiment, the said remote computer is selected for the ability to communicate with the said microcontroller or perhaps indirectly with a system computer that communicates with the said microcontroller by wired or wireless means. Collectively, data from the microcontroller is the means to use artificial intelligence algorithms to make an probabilistic identification of the causes of stress; predict the type of damage being wrought; estimate the degree of damage incurred; estimate the remaining useful life before failure occurs to the conduit. The remote computer provides the means to communicate in real or elapsed time to persons who are at risk, who provide maintenance services, or who otherwise need to be aware of deterioration, damage, or risk thereof to the conduit and the services it provides.

In the preferred embodiment, the said pattern of a multiplicity of strands is connected with the said microcontroller at least at one end. Situations may arise when a microcontroller is required at another end of the conduit. This can be readily accomplished with a wireless, light emitting, or wired commercial technology such as BlueToothTM. In the preferred embodiment the discrete sensors will be placed for maximum effectiveness and if necessary the sensors could be connected to a commercial wireless technology like BlueToothTM to enable performing functions such as sensing for end-to-end continuity tests.

In the preferred embodiment, processing provides a means collecting a life history, beginning with operating in a birth certificate mode wherein the outputs of the sensors are processed and stored as baseline operational parameters; and means for operating the monitoring device in a monitoring mode, after the processor has operated in the birth certificate mode the process acquires, conditions, and processes the outputs from the sensors, compares the processed outputs to the baseline operational parameters, resets the baseline if programmed to do baseline updateing, and provides an indication of the condition of the conduit based on the comparisons; and when risk of damage or actual damage to the health and integrity of the a conduits, takes action in the form of alerts by messaging along with initiating control actions to limit damage to the conduits and the effects thereof.

A person familiar with sensoring with measurement of Optical Phenomena_would understand that in the case of very long conduits perhaps over 1000 meters, it may be necessary to add additional processors at distanced points, probably at connectors as determined by the range of effectiveness of individual sensors.

While the current invention is described mostly in connection with a presently preferred embodiment thereof, those skilled in the art will recognize that any modifications and changes may be made therein without departing from the true spirit and scope of the invention, which accordingly is intended to be defined solely by the appended claims. For instance, in most figures three distinct sensor elements are shown, but there could be any number arranged in any order. Any person familiar with performing tests for conductivity and reflectometry will concur that any number of sensitized media laid in patterns of any non-interfering arrangement can be utilized.

All of the embodiments above offer the following advantages over present techniques. The present invention detects many damages other than chafing caused by many other causes than abrasion or incision. It matters not whether the conduit is operating or not operating. The present invention detects damage due to virtually all and every stressor by selecting sensitized strands specific to each damaging factors of each stressor. The present invention can be implemented to operate from manual to fully automatic.

Clearly, many modifications and variations of the present invention are possible in light of the above teachings. Which embodiment to employ depends on the application. The choice should be left to system engineers and experts in operating the systems to be protected. It should be therefore understood that, within the scope of the inventive concept, the invention may be practiced otherwise than as specifically claimed.

Operation -Preferred Embodiment

Operation of the invention is accomplished by selecting and procuring or making the sensitized sensor medium appropriate to the environment, damage causing factors, and the conduit; assembling the largely parallel arrangement of said strands onto the support media; adding the points and connections to the electronics (if any), adding appropriate sensors (if any); and authoring algorithms and rules for running in the microcontroller (if any); installing the apparatus onto or into the conduit; performing tests for operability; install the apparatus onto or into the conduit; activate with a suitable power source (if any).

When forming the sensor medium onto the support medium it is prudent to encircle the segments of the conduit with a tightly spaced helix of sensitized media joined as necessary by couplings that accomplish continuity. In the preferred embodiment, depending on the sensitized media it may be necessary to attach a lead from a measurement instrument and a lead from a signal source to opposite ends of said sensitized media for the purpose of collecting and interpreting changes in data caused by stressors

The sensor medium should be in contact with the surface of the conduit. If a heat shrinkable substrate is used, the embodiment is heated appropriately to tightly affix the embodiment to the segments of the interconnection assembly. In operation the sensitized media encasing the segments will be affected by stressors operating on them. End to end tests or tests such as reflectometry can be used to detect damage to any sensitized media able to carry the waveforms. On detection of said damage the computer uses algorithms such as trending, pattern matching, fuzzy logic, distance calculation, logic, inference and data fusion to determine the type, location and cause of the damage as well predict future impacts of the damage if damage is allowed to progress into the protective insulation and eventually the conducting core. Next, the results of the detection, location, and determination of cause are used to initiate or request actions that mitigate or remove the stressor or stressors that are the cause of damage as well as corrective actions to bypass, repair or otherwise deal with the damage. During said actions the damage to the interconnection system is repaired and damaged and sections of the sensitized media used in the embodiment of the invention are replaced or repaired.

REDUCTION TO PRACTICE (page 25)

No Changes, Additions, or Deletions